TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

No. 296

EXPERIMENTAL DETERMINATION OF PRESSURE DROP CAUSED BY WIRE GAUZE IN AN AIR STREAM.

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Summary

For several kinds of wire gauze the differences in static, dynamic and total or absolute pressure in front of and behind the gauze were determined for comparison with the pressure drop caused by an airplane radiator, such gauze being used on airplane models to represent the radiator.

1. Reason for the investigation.- In testing airplane models in a wind tunnel, it was desired to include the radiators. The effect of the latter on the wind forces is of two kinds. In the first place, they offer a certain resistance of their own and, in the second place, they affect the resistance offered by other parts. In making a model, both these effects should be made to correspond, as far as possible, to the real. The pressure drop caused by the radiator, i.e., the pressure difference before and behind the radiator, was taken as the basis of this comparison. On the model, the radiator was represented by a piece of wire gauze of the same shape and of such kind as to cause the same pressure drop.

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2. Description of gauze employed.- In order to find the gauze possessing, from the above viewpoint, the same value as an ordinary radiator, we tested five kinds of wire gauze with square meshes of different widths and wires of different diameters. Table I gives a summary of the kinds of gauze tested, with the serial numbers by which we shall continue to designate them; width of mesh measured from center to center of the wires; diameter of wire in millimeters; and the "wire area," or ratio of area covered by the wires to the total area covered by the gauze. The different kinds of gauze form no systematic series, since they had to be selected from the kinds available.

3. Method of testing.- In pressure determinations in an air stream, there are three important quantities. In the first place, the "static pressure" (which is the pressure at the testing point when the air stream is not disturbed) was measured with the lateral openings ("static-pressure openings") of a Pitot tube.

In the second place, the absolute pressure (which arises at the testing point when the velocity is reduced to zero and which is the case of the foremost point of every revolving body) was measured with the foremost opening of a Pitot tube. According to Bernouilli's equation, the absolute pressure is

$$p_2 = p_3 + \frac{1}{2} \rho v^2$$

in which p_2 = total pressure, p_3 = static pressure, ρ = density of air, v = wind velocity.

The dynamic pressure $p_1 = \frac{1}{2} \rho v^2$ is the third important quantity and was found as the difference in pressure between the two openings of the Pitot tube.

Kumbruch demonstrated that the measurement of these pressures with a Pitot tube in a turbulent air stream may produce errors.* Probably the kind of turbulence makes a difference, concerning which, however, there are no reliable data. It is here assumed that this difference is not great enough to forbid comparison.

In the present instance, the absolute pressure is the most important quantity. In the air flow about a body, the static and dynamic pressures change rapidly from point to point, while the absolute pressure remains constant, except when there is a loss of energy due to friction and the formation of vortices. For this reason also, the absolute pressure is taken as the basis of comparison.

In this experiment the wire gauze was stretched over square frames measuring about 60 cm (23.6 in.) on a side. The frames were made of metal of 4 or 10 mm (0.16 or .39 in.) diameter and was suspended in the middle of the air stream on small steel wires. The experiment was made in the open air stream, in order to facilitate installation and reading. The pressure measurements were made with a Pitot tube of the standard N.P.L. type and a liquid micromanometer. The pressures p_1, p_2 and p_3 were measured at about 10 cm (3.9 in.) behind the gauze. In measuring the pressures p_2 and p_3, the open end of the manometer was connected with an opening in the wall of the tunnel, in order to obtain a constant reaction. The absolute

*Kumbruch, H. "Messung strömender Luft mittels Staugeräten," in "Forschungsarbeiten auf dem Gebiete des Ingenieurswesens," No. 240.

pressure was measured only at a point about 30 cm (11.8 in.) in front of the middle. The static and dynamic pressures are smaller at this point, since here the damming effect of the gauze is very noticeable, which was thus found to depend on the location of the testing point. For comparison with the pressure measured behind the gauze, the static and dynamic pressures of the undisturbed air stream can therefore be taken better here and can be regarded as pressures measured at an infinite distance from the gauze. The measurements were taken at five different velocities of 11 to 26 m (36.1 - 85.3 ft.) per second.

In addition to the tests made with each gauze separately, measurements were also made of the pressure difference before and behind gauzes Nos. 1 and 2 taken together, with a space of about 10 cm (3.9 in.) between them. In this case, the measuring points were 30 cm (11.8 in.) before the front and 10 cm (3.9 in.) behind the rear gauze, the No. 1 gauze being placed in front.

4. Results.- The relative values are obtained by dividing the measured values by the dynamic pressure of the corresponding undisturbed flow. The figures for the separate gauzes are given in Table II and for both gauzes together in Table III. In both tables the values of p_1/p and p_3/p are omitted for the measurements in front of the gauze, because these are always 1 and 0 respectively, as the result of the assumption made in section 3. The last three columns in both tables give the differences between the pressures before and behind the gauze.

The results were probably somewhat affected by variations in velocity, which it was impossible to keep absolutely constant. Hence, for mutual comparison, the mean values are given in Table IV. These show, as was to be expected, that the pressure difference increases with increasing fineness of the gauze. Gauze No. 2 seems to be an exception to this rule, for which no explanation can be given.

The pressure drop for the two gauzes placed one behind the other is less than the sum of the pressure drops for the same two gauzes taken separately. Placed one behind the other, they may be considered as equivalent to a finer gauze, which, as regards its aerodynamic properties, approximately corresponds to gauze No. 4. A space between the two gauzes seems to make some difference, which can be attributed to the modified effect of the rear gauze on the already turbulent flow.

5. Comparison with a radiator.- Table V gives, for the sake of comparison, the corresponding values for the radiator shown in Fig.1,

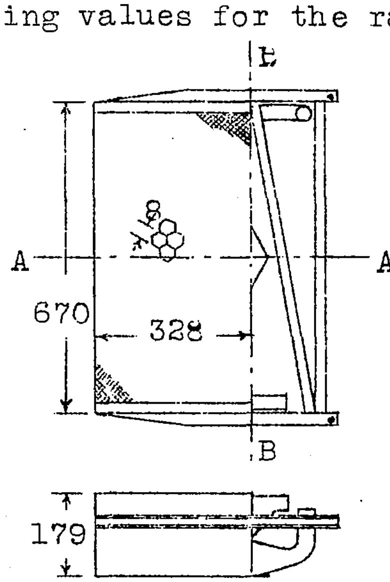

Fig.1 Radiator from Fokker C IV airplane

which was from a Fokker C IV airplane. The experiment was executed in the same manner as with the gauze. As regards the absolute pressure, this radiator corresponds approximately to gauze No. 3. Although the static and dynamic pressures in both cases give different results, it is considered, on the basis of section 3, that this gauze satisfactorily represents the radiator. Gauze No. 3 is therefore used in the place of the radiators on airplane models, when the radiator to be represented does not differ too much from the one mentioned above.

Translation by Dwight M. Miner,
National Advisory Committee
for Aeronautics.

Table I.

Different Kinds of Gauze.

No.	Mesh width mm	Mesh width in.	Wire diameter mm	Wire diameter in.	Wire area (Ratio to whole area covered by the gauze.)
1	4.5	.177	0.9	.035	0.360
2	2.9	.114	0.5	.020	0.315
3	2.0	.079	0.6	.024	0.510
4	1.5	.059	0.4	.016	0.462
5	1.125	.044	0.4	.016	0.585

Table II.

Dynamic Pressures in the Undisturbed Air Stream.

Gauze No.	V m/sec	V ft/sec	Before p_2/p	Behind p_1/p	Behind p_2/p	Behind p_3/p	Difference before and behind p_1/p	Difference p_2/p	Difference p_3/p
1	11.6	38.1	0.99	0.60	0.40	-0.21	0.40	0.59	0.21
	16.3	53.5	1.01	0,62	0.39	-0.22	0,38	0,62	0.22
	20.0	65.6	1.01	0.64	0.42	-0.22	0.36	0.59	0.22
	23.1	75.8	1.01	0.66	0.42	-0.23	0.34	0.59	0.23
	25.9	85.0	1.00	0.67	0.43	-0.24	0.33	0.57	0.24
2	11.6	38.1	1.00	0.68	0.49	-0.19	0.32	0.51	0.19
	16.3	53.5	0.99	0.69	0.51	-0.19	0.31	0.48	0.19
	20.0	65.6	0.99	0.70	0.51	-0.20	0.30	0.48	0.20
	23.1	75.8	0.97	0.69	0.49	-0.20	0.31	0.48	0.20
	25.9	85.0	0.99	0.67	0.47	-0.21	0.33	0.52	0.21
3	11.6	38.1	0.99	0.63	0.38	-0.23	0.37	0.61	0.23
	16.3	53.5	1.02	0.63	0.39	-0.24	0.37	0.63	0.24
	20.1	65.9	1.02	0.64	0.43	-0.24	0.36	0.59	0.24
	23.2	76.1	1.02	0.62	0.38	-0.25	0.38	0.64	0.25
	25.9	85.0	1.02	0.63	0.38	-0.25	0.37	0.64	0.25

V = Wind velocity in m/sec. (ft./sec.)
p = Dynamic pressure of undisturbed air stream in kg/m²
p_1 = Dynamic pressure in kg/m²
p_2 = Absolute pressure in kg/m²
p_3 = Static pressure in kg/m²

Table II (Cont.)

Dynamic Pressure in the Undisturbed Air Stream.

Gauze No.	V m/sec.	V ft/sec.	Before p_2/p	Behind p_1/p	Behind p_2/p	Behind p_3/p	Difference before and behind p_1/p	Difference before and behind p_2/p	Difference before and behind p_3/p
4	11.5	37.7	1.01	0.41	0.12	-0.31	0.59	0.89	0.31
	16.2	53.1	1.03	0.44	0.13	-0.31	0.56	0.90	0.31
	19.7	64.6	1.02	0.43	0.13	-0.31	0.57	0.89	0.31
	22.9	75.1	1.03	0.46	0.14	-0.32	0.54	0.89	0.32
	25.6	84.0	1.03	0.46	0.14	-0.32	0.54	0.89	0.32
5	11.5	37.7	1.01	0.31	-0.02	-0.35	0.69	1.03	0.35
	16.2	53.1	1.02	0.34	-0.01	-0.34	0.66	1.03	0.34
	19.9	65.3	1.01	0.34	0	-0.34	0.66	1.01	0.34
	23.0	75.5	1.03	0.31	-0.03	-0.35	0.69	1.06	0.35
	25.7	84.3	1.03	0.31	-0.04	-0.36	0.69	1.07	0.36

V = Wind velocity in m/sec. (ft./sec.).
p = Dynamic pressure of undisturbed air stream in kg/m²
p_1 = Dynamic pressure in kg/m²
p_2 = Absolute pressure in kg/m²
p_3 = Static pressure in kg/m²

Table III.

Gauzes Nos. 1 and 2 Behind One Another.

Dynamic Pressure in the Undisturbed Air Stream.

Distance between gauzes. mm	V m/sec.	V ft/sec.	Before p_2/p	Behind p_1/p	Behind p_2/p	Behind p_3/p	Difference before and behind p_1/p	Difference before and behind p_2/p	Difference before and behind p_3/p
0	11.6	38.1	0.96	0.44	0.18	-0.27	0.56	0.78	0.27
	16.3	53.5	1.02	0.45	0.16	-0.29	0.55	0.86	0.29
	20.0	65.6	1.02	0.46	0.14	-0.31	0.54	0.88	0.31
	23.1	75.8	1.00	0.49	0.13	-0.32	0.51	0.87	0.32
	25.9	85.0	1.01	0.52	0.15	-0.32	0.48	0.86	0.32
100 (3.9 in.)	11.5	37.7	1.00	0.40	0.16	-0.25	0.60	0.84	0.25
	16.3	53.5	1.00	0.41	0.15	0.25	0.59	0.85	0.25
	20.0	65.6	1.00	0.42	0.15	-0.26	0.58	0.85	0.26
	23.0	75.5	1.00	0.43	0.17	-0.27	0.57	0.83	0.27
	25.7	84.3	1.00	0.42	0.16	-0.27	0.58	0.84	0.27

See Table II.

Table IV.

Mean Values of Difference Given in Tables II and III.

Gauze N_2	p_1/p	p_2/p	p_3/p
1	0.36	0.59	0.22^5
2	0.31^5	0.49^5	0.20
3	0.37	0.62	0.24
4	0.56	0.89	0.31^5
5	0.68	1.04	0.35
1 + 2 (distance 0)	0.53	0.85	0.30
1 + 2 (distance 100)	0.58^5	0.84	0.26

Table V.

Radiator from Fokker C IV Airplane.

Dynamic Pressure in the Undisturbed Air Stream.

V		Before	Behind			Difference before and behind		
m/sec	ft/sec.	p_2/p	p_1/p	p_2/p	p_3/p	p_1/p	p_2/p	p_3/p
11.6	38.1	0.99	0.40	0.31	-0.12	0.60	0.68	0.12
16.3	53.5	0.99	0.42	0.27	-0.14	0.58	0.72	0.14
20.0	65.6	0.98	0.41	0.30	-0.15	0.59	0.68	0.15
23.1	75.8	0.99	0.40	0.31	-0.15	0.60	0.68	0.15
25.9	85.0	0.99	0.43	0.30	-0.15	0.57	0.69	0.15
				Mean	. . . .	0.59	0.69	0.14

See Table II.